A Geospatial Analysis of Animal Movement: Why did the elephant cross the Zambezi?

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Introduction

The northern border of Zimbabwe is the centerline of the Zambezi River. On the other side of the border is Zambia. A group of researchers studying human-elephant conflict in and around the town of Victoria Falls, is interested in understanding why, when and where elephants cross the Zambezi River. Researchers from the University of Georgia, Salisbury University and Bridgewater State University in the U.S. are collaborating with scientists from Connected Conservation and the Victoria Falls Wildlife Trust located in Zimbabwe to tag 22 bull African elephants with GPS collars, experiment with mitigation measures and analyze spatio-temporal patterns of transboundary movement. All the tagged elephants were identified as problem animals engaging in breaking fences, crop raiding, and threatening local residents (Karidozo et al. 2016, Lindsay et al. 2017, Langbauer et al. 2021). Although the bulls primarily live, roam and forage in Zimbabwe, many of them do cross the river and the border into Zambia. Our study area falls within a designated cooperative conservation area, the Kavango-Zambezi Transfrontier Conservation Area or KAZA for short shown in Figure 1, that includes the length of this border upstream of the world-famous Victoria Falls (TFCA 2020).

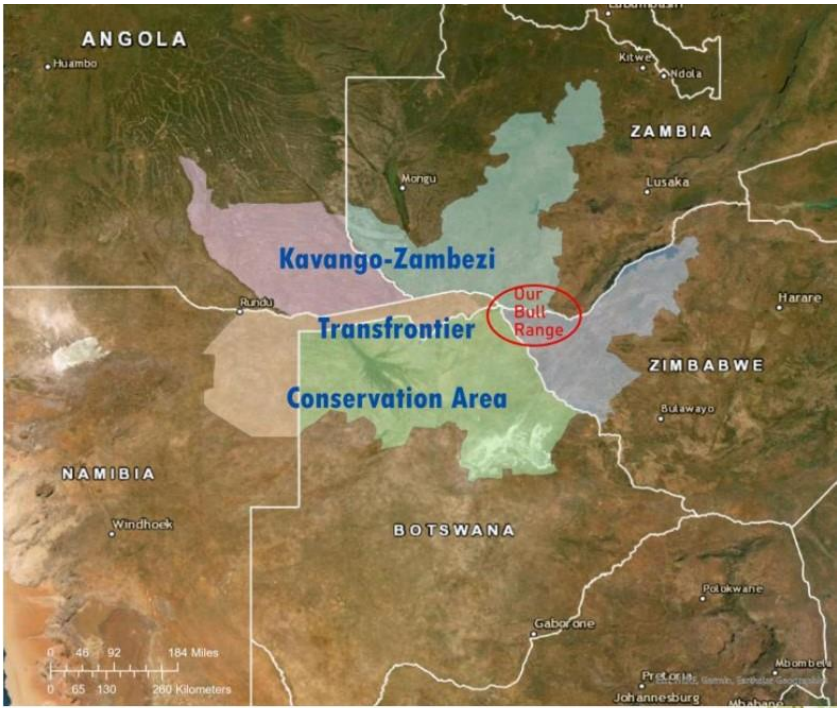

Figure 1: Kavango-Zambezi Transfrontier Conservation Area (KAZA). Our study area is circled in red.

While the conservation efforts are cooperative, there are still transboundary complications, and policy issues that arise when a Zimbabwean elephant is involved in a human-wildlife conflict incident in Zambia. This is one reason why it is important to understand the drivers of elephant cross-border activity and the spatial-temporal patterns of bull movement in and around the Zambezi River. Having this information would also be critical for planned development of lodges, restaurants, and tourist attractions along the Zambezi, so that human-elephant conflict can be minimized (Karidozo et al. 2021).

Method

This ongoing research analyzes the environmental variables of terrain (elevation & slope variations), land cover, precipitation, soils, and seasonal change, along with human activity, to model predictive factors attracting these bull elephants to the river, the riverbanks, and the islands in the river (ASTER GDEM 2009, ESA 2017). This presentation focusses on the terrain analysis. We used GPS data collected in 15-minute to one-hour increments from collars that were placed on the elephants over a 5-year period (2017-2022). Key features in the analysis of the bull movement are the tracks or paths that are created from the points. Using tools to create these paths at the same time keeping all points and attribute data takes a bit of mix processing between Python and ArcGIS Pro tools. Th the flow of this process is shown in Figure 2.

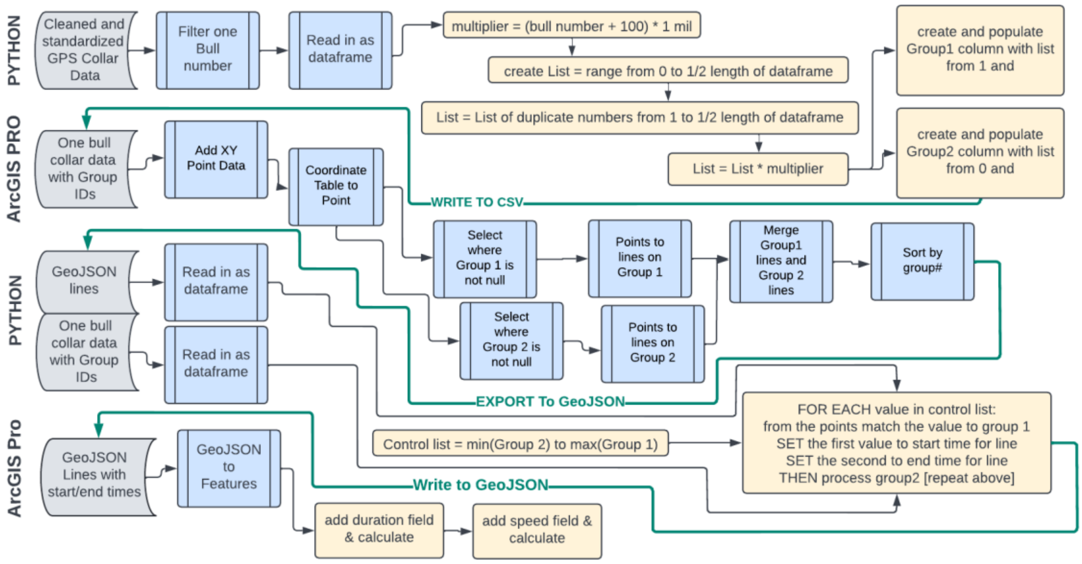

Figure 2: Flow diagram of the process to convert GPS collar point data to line segments maintaining bull ID and time intervals between actual points.

The tracks were then used to visually determine corridors most frequently used by the elephants (Figure 3). The tracks were also overlayed on to elevation and slope (Figure 4) analyses maps of the areas. Line and kernel density maps were also produced to compare with the visual overlay analysis.

Figure 3: Elephant tracks crossing the Zambezi at Victoria Falls, Zimbabwe

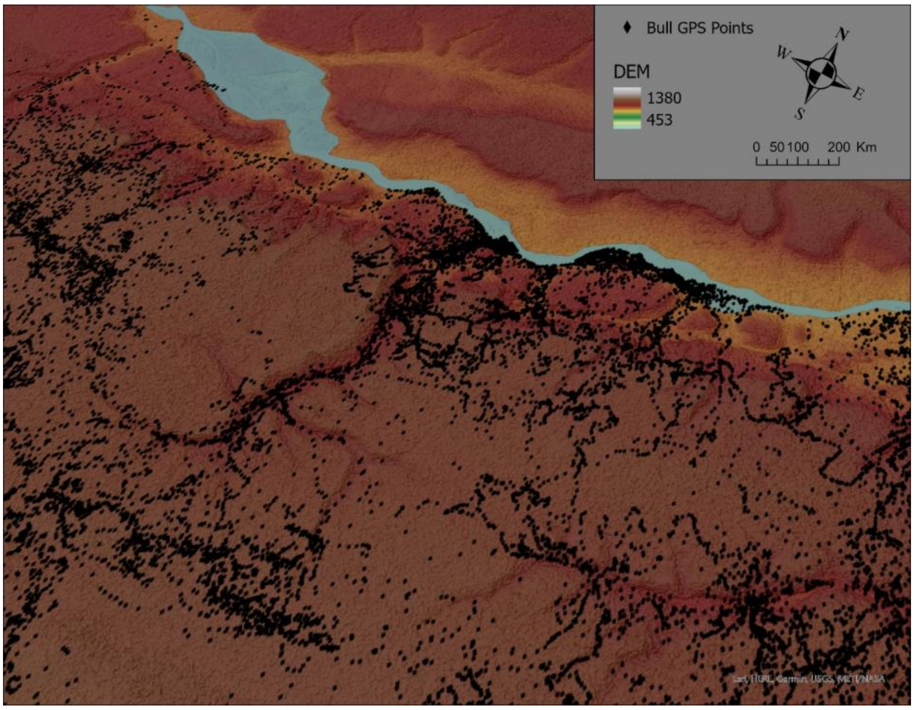

Figure 4: Elephant GPS points showing heavy use of ravines to and from the Zambezi Rive, using an exaggerated elevation and hill shade model.

Results

This analysis is focused on elephant movement near and across the Zambezi River relative to terrain and topography. Results show a high density of points and paths used are those with the lowest slope or elevation change such as ravines, dry stream beds, and point bar areas along the river. Line, kernel density, and heat maps were utilized to visualize these trends. Figure 5 shows a heat map hightlighting the main crossing points that have been identified. Tracks and GPS points were clipped to a 3.5 km buffer around the river to focus the density models to movement closest to the Zambezi.

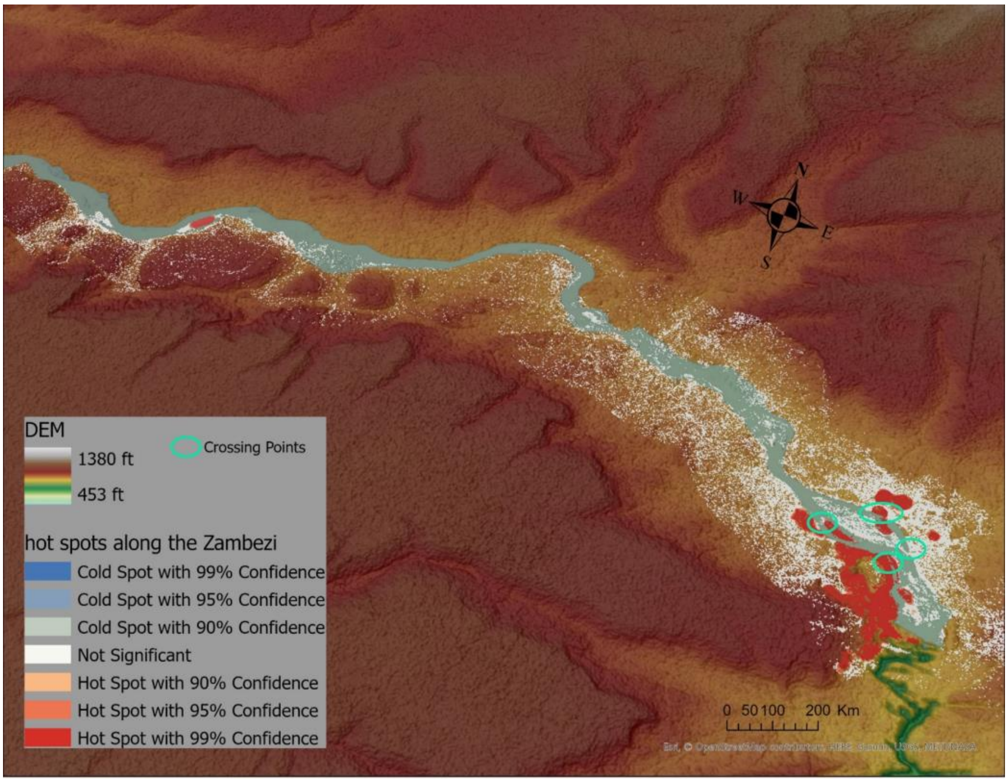

Figure 5. Heat maps of elephant GPS points clipped to 3.5-km buffer around the Zambezi with crossing points that are identified in Figure 3 highlighted.

Discussion and Conclusion

Through studying bull elephant tracks in and around the Zambezi River in relation to slope and elevation it was observed that:

1. Terrain, changes in elevation, plays a role in the bulls' path choice; and
2. Bulls use paths of lesser slope when available.

Using the slope definition from the UN Food and Agriculture Organization (Brouwer, Goffeau & Hejbloem 1985) five categories were selected Flat to Gentle: < 5 % , Slight Rise: 5 to 10%, Moderate Rise: 10 to 25% and Steep: > 25%. Counts of GPS points at in each category were extracted. From 22 elephants over a 5-year period 442,693 good GPS points were used. Table 1 shows the generalized category, count, and percent of total.

Slope Category	Count of GPS Points	Percent of Total
Flat to Gentle: < 5 %	315,126	71.18%
Slight Rise: 5 to 10%	114,945	25.96 %
Moderate Rise: 10 to 25%	12,514	2.82 %
Steep: > 25%	108	0.02 %

Table 1.

Just over 71% of all points were on gentle slopes and another almost 26% were on slight slopes between 5 to 10 % grade resulting in over 97% of all points on slopes of 10% or less.

In the future, to better answer the question "Why did the Elephant cross the Zambezi" we need to perform the following.

- Expand the study beyond the Zambezi River border area for terrain analysis, and particularly look at the Botswana border as well.
- Conduct local land use/land cover, land development, private land, fruit trees, and small gardens surveys to see in more detail what vegetation may be attracting the elephants/
- Obtain or produce a high-resolution soil map that will help determine if certain soils are favored or avoided by the bulls.

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